

## Fiber Flax Farming Practices in the Southeastern United States

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Foulk, J. A., Akin, D. E., Dodd, R. B. 2003. Fiber flax farming practices in the southeastern United States. Online. Crop Management doi: 10.1094/CM-2003-0124-01-MG.

### Abstract

Flax fiber and oilseed use is increasing in textiles, composites, paper/pulp and industrial/nutritional oil sectors in the U.S. As a winter crop, flax fits well into double-cropping systems in the southeastern U.S. Flax can be harvested as an early crop for fiber, with attached immature seeds, or harvested as a late, mature crop, for both seed and fiber production. Flax can be grown and harvested for fiber using equipment that is readily available and well understood by U.S. farmers.

### Overview

Flax is an agricultural crop that can provide food (14), fuel (2), and fiber (22). Worldwide, flax is grown on 12 million acres (12). In 2001, according to tariff and trade data from the U.S. Department of Commerce, the U.S. imported flax and linen (fiber, yarn, fabric and clothing) with a customs value of more than 39 million dollars. Globally, the U.S. is the largest per capita consumer of flax fiber and all of the industrial grade fiber is imported.

Over the years, fiber and seed flax (*Linum usitatissimum* L.) have been grown successfully across a large region of the U.S. (12,23,20). Compared to flax grown for seed, fiber flax plants are taller, have fewer branches, produce more fiber, have a lower oilseed content and produce less seed (1). Flax fiber has customarily been divided into two classes, namely long-line fiber and tow. Tow is a byproduct of long-line fiber production and consists of short staple fibers. Short staple spinning units dominate North American textile mills; no long-line flax fiber processing facilities are operating in the U.S.

Fall flax production in the southeastern U.S. has the potential to enhance rural economic growth and to supply a domestic source of fiber to industries. Kingstree, South Carolina, is the location of a newly organized flax fiber processing company, which currently depends on local farmers to produce flax on approximately 1200 acres to supply fiber for its commercial processing plant. North Carolina and New Jersey are home to two different paper-manufacturing facilities that utilize approximately 275,575 tons of refined Canadian flax fiber per year (6). An automobile composites company located in Canandaigua, New York, uses approximately 750 tons of refined Canadian fiber each year.

Many individuals, companies, and agricultural experimental stations have attempted to grow flax in the southeastern U.S. during the summer. Often, flax stands established well but died with the arrival of hot and dry weather (20). Fiber flax grown during the summer in the southeast was of inferior quality with low yields. In contrast, Foulk et al. (8), Frederick (2000, unpublished data), Loadholt (11), and Parks et al. (16) established that flax could be grown as a winter crop in the southeastern U.S. with stalk yields around 6,000 lb/acre.

Fiber flax can be produced in the southeastern U.S. using the new production system designated Clemson Fiber Flax (CFF). CFF is a system that optimizes flax fiber yield and quality by identifying field preparation, planting date, and harvest techniques that producers in the southeastern U.S. can readily adopt.

### Flax Plant Characteristics

Fiber flax is an annual plant that grows for 90 to 180 days to a height of around 48 inches when sown in high density (16). Disease-resistant varieties of flax perform best during cool and moist weather on fertile silt to clay loams with proper crop rotation (10). The long strong bast fibers for further processing are found between the bark and core (23). The plant produces a stem approximately 0.04 to 0.08 inches at the base with 80 to 100 leaves and 5 light-blue, white, or pink petals (Fig. 1) (23). Flax produces seed capsules containing 10 seeds and is primarily self-pollinated with some pollination due to insects (15). The root system contains no bast fiber (18). The root system of flax is less extensive than many other crops, and therefore it is less competitive for moisture (10). Newer flax varieties demonstrate increased yields of straw, fiber, and seed as well as greater resistance to diseases and lodging compared to older varieties.



Fig. 1. Fiber flax bloom with light blue petals in South Carolina.

### Planting and Protection



Fig. 2. Fiber flax seedlings in a flat, firm, and uniform field in South Carolina.

The southeastern U.S. has a long growing season and mild winters which allow growers to potentially produce a winter crop of flax (4). The CFF production system involves precise seedbed preparation for planting. Flax seedlings have difficulty emerging from crusted soils and are sensitive to hot and dry conditions during growth. A good seedbed includes weed control, conservation of soil moisture and a flat (few large clods), uniform, and firm seedbed for germination (Fig. 2). In addition, since the plants will be mowed using a drum mower, a flat and even field provides the greatest harvest efficiency (resulting in less stubble) as plants are uniformly cut at the soil's surface.

The seedbed can be prepared using a disc harrow and field cultivator or any other combination producing a flat and uniform field. Seeds should be broadcast or drill planted with a row spacing of roughly 7 inches and approximately 0.4 inches deep with the depth never to exceed 1 inch. Fiber flax varieties are planted closer together than seed flax varieties so that only the main stem develops and the plants grow tall with fewer branches and seeds, thus producing long, fine, and strong fibers. Parks et al. (16) reported that 110 lb seeds per acre is the desired seeding rate for fiber flax. Flax tolerates a wide range of soil types but does best on fertile, well-drained, medium to heavy textured soils (10). Well-drained loamy or silty soils are desirable for planting with subsoil clay or B-horizon within 12 inches of the surface more desirable (16).

Before planting, the soil pH should be between 5.8 and 6.5. In the absence of direct recommendations for flax, the fertilizer rates suggested for production of small grains can be followed. According to Frederick (2000, unpublished data), a general target for nitrogen, phosphorous, and potassium in the soil would be 70, 60, and 150 lb/acre. Loadholt (11) evaluated the influence of nitrogen, phosphorus, potassium, and micronutrients on poor and well-drained coastal plain soils. Management of nitrogen is critical with a total of 70 to 80 lb of nitrogen per acre for residual and added nitrogen necessary (1,12,16,23).

Nitrogen should not be placed next to the seed (1), and excessive nitrogen should be avoided as it encourages weed growth and lodging without enhancing fiber production. Flax plants are sensitive to zinc deficiency (16,23); however, micronutrient fertilization is seldom recommended (1).

The growing practices for fiber and seed flax are comparable (13), which allows use of flaxseed herbicide (3,9,12), pesticide (1,3,9,12), fertilizer (1,3,9,12,17,24), and insecticide recommendations (1,3,9,12). Flax seedlings do not compete well with other plants, and yield and quality are improved with weed control. Herbicides on seed flax are superior to post-plant tillage techniques in controlling weeds in flax (5). The herbicides Treflan® or Treflan EC® are used prior to planting with post-emergence herbicides such as Buctril®, MCPA®, or Poast® applied when the flax plant is between 2 and 8 inches (16). Management strategies, crop rotation, different varieties, environmental conditions, soil types, and controls may be required to avoid disease and plant problems (1,9,15,17). To guard against diseases, a four-year crop rotation of disease-resistant varieties is recommended along with a seed treatment such as Thiram (16).

Depending upon the location within the southeastern U.S., seeds planted between October and December benefit from the cool and moist weather. Flax benefits from this cool and wet weather since the plant requires adequate soil moisture from planting until flowering. Flax grows well with frequent, low volume irrigation (10). To benefit from weather conditions planting should be done as early as possible; crops grown in portions of Arizona, California, and Mexico are planted from November through December (7). Temperatures below 28°F can kill flax in the seedling stage so flax is planted along the coast in South Carolina, Georgia, and Louisiana between October 15 and November 10. In some instances, temperatures below 15°F have killed fiber flax plants, with these deaths typically related to the time that plants are exposed to these temperatures. Flax grown in Texas is sown from late November through early December. For locations further north such as Virginia and Tennessee, flax is planted in March (20).

### Harvesting and Retting

Flax roots do not contain fiber so it is not necessary to harvest the entire plant. The time of harvest is influenced by climatic conditions and the crop's final use (Fig. 3). Harvesting of flax at different maturities according to the CFF process provides a diversity of products: (i) early crop for fiber only, with attached immature seeds for greater fiber quality, or (ii) mature crop for both seed and fiber production (19). The finest fibers are obtained by harvesting the crop following a full bloom with the stem and leaves green or at medium fiber fineness when half to a third of the seed bolls are yellow and brown with fully-developed seeds (19). According to the CFF process, flax is cut with a drum mower (Fig. 4). When harvesting with a drum mower, changes such as mower blade angle and tractor speed relative to the greenness of plants, as well as operator skill, field preparation, planting, and harvesting techniques affect the height of the flax left in the field as stubble.



Fig. 3. Fiber flax crop near maturity in South Carolina.



Fig. 4. Drum mower to harvest flax fiber as an early crop for fiber only or as a mature crop for both seed and fiber production in South Carolina.

Flax that has been naturally dried or sprayed with a desiccant produces a dry, usable seed. To harvest flax for seed requires relatively dry stalk material; otherwise stalks clog the stripper header of the combine. Harvesting flax at maturity according to the CFF process requires that the seeds be first removed from stalks with a stripper header attached to a grain combine (Fig. 5). In combining, seeds are easily damaged so the condition of the seed determines the harvesting speed. Flaxseed can be safely stored at moisture levels of 10.5% or lower (3). The deseeded stalks are then drum-cut, field-dried, and raked (Fig. 6) for even dew-retting and drying. Flax straw should be raked into windrows and baled using standard hay baling protocol such as straw dryness, baler setting, bale density, speed, and packaging.



Fig. 5. Grain combine with stripper header for detaching fully-developed flaxseeds prior to fiber production in South Carolina.



Fig. 6. Mowed fiber flax straw raked for consistent dew-retting in South Carolina.

The fine bast fibers are released from the stem by a process termed *dew-retting*. Mowed flax is dew-retted according to weather conditions and completed in a week (when weather is warm and moist) to months (when weather is cold and dry) (18). In this process, indigenous fungi and bacteria partially decompose the plant stems of flax. These organisms produce enzymes capable of degrading the non-fibrous tissues in flax stems with an influence on the quality of the fiber. Through enzymes, the selective biodegradation of the pectinaceous and matrix substances facilitates the removal of cellulose fibers from the woody portion of a flax plant (21). Due to weather conditions, dew-retting is uncertain and so it is important to form a uniform layer of mowed flax stalks and, if possible, rake the crop for consistent retting.

Flax stalks can be over-retted, which produces fibers of substandard strength due to the decomposition of the cellulose fibers. Many variables, including temperature, moisture, organisms, mowed straw layers, and raking, influence retting and so the stems must be inspected periodically for harvest optimization. Higher temperatures and moisture increase the activity of microorganisms that degrade the pectin while non-uniform straw layers created during raking can create varying zones of retting. Dew-retting is subjectively judged and considered complete once the fibers appear silver and separate easily from the stem. Following dew-retting, the fibers are then dried for baling and further processing (Fig. 7). According to the CFF process, flax can be baled using a round or square hay baler (Fig. 8) for fiber processing.



Fig. 7. Round hay baler to harvest dew-retted flax fiber in South Carolina.



Fig. 8. Round bales of flax produced on a flat, firm, and uniform field in South Carolina.



## Summary

As with any crop, intelligent farming is required to produce high quality and profitable flax. Flax production costs parallel other small grain production crops in the southeastern U.S., indicating it may be a supplementary crop for idle lands. No costly, specialized harvesting equipment is required using the CFF system. Research shows that high-quality, short-staple fibers are found in early-harvested flax and from mature flax harvested for seed and fiber. The CFF system in conjunction with new processing methods allow the production of a domestic, commercial source of flax fiber for textile, composite, and paper industries. Flax as a winter crop for fiber, especially in double-cropping with high value summer crops, has the potential to enhance the income of local industries in the southeastern U.S.

## Acknowledgements

Mention of specific products is for information purposes only and is not to the exclusion of others that may be suitable. The contributions of James Frederick to this work are gratefully acknowledged and appreciated.

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